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STATE OF CALIFORNIA

The Resources Agency

Department of Water Resources

BULLETIN No. 192

# PLAN FOR IMPROVEMENT OF THE DELTA LEVEES



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CLAIRE T. DEDRICK  
Secretary for Resources  
The Resources Agency

EDMUND G. BROWN JR.  
Governor  
State of California

RONALD B. ROBIE  
Director  
Department of Water Resources



*Brannan-Andrus Islands and the town of Isleton under water as a result of levee failure in June 1972.*

## ARTMENT OF WATER RESOURCES

BOX 388  
MENTO  
902

Honorable Edmund G. Brown Jr., Governor  
Members of the Legislature of the  
State of California

Gentlemen:

I am pleased to transmit to you this report on the Sacramento-San Joaquin Delta levees. It describes a general plan of improvement which would upgrade flood protection in the Delta, preserve the Delta channels, retain their configuration, and enhance the Delta's great economic and environmental values, including establishing levee vegetation to improve recreation, wildlife, and esthetics. The report also presents a suggested distribution of the cost of improvements among federal, state, and local governments.

The California Legislature in 1969, requested the Department under Senate Concurrent Resolution No. 151, to study the problems relating to Delta levees and recommend a course of action to implement feasible solutions to the problems. In September 1973, an interim report entitled "Delta Levees, What is Their Future?" was completed. That report presented four alternative courses of action for the Delta levees which could be followed. The alternatives provided for differing degrees of improvement ranging from no improvement to extensive improvement.

Public meetings were held in Sacramento, Isleton, Los Angeles, Stockton, and Oakland to hear comments on the interim report. Many written comments also were received. The two most widely expressed views were (1) preserve the character of the Delta including its channel configuration essentially as it is today, and (2) provide better flood control through improved multiple-purpose Delta levees. All comments were considered in the selection of the plan of improvement described in this report.

I recommend the Legislature review and possibly hold public hearings on this report for the purpose of adopting the recommended plan and a means of financing the State's share of the costs. Federal participation would be essential to the recommended program; therefore, I also recommend the Legislature urge the U. S. Army Corps of Engineers to expedite its studies of the Delta levees and review of the proposed plan of improvement to ascertain federal financial participation in the program. Moreover, because of the need to expedite a program for protection of the Delta, the State should be the prime agency responsible for the reconstruction of the Delta levees.

Environmental impact reporting requirements will be met before definitive plans of specific levee reconstruction projects are approved.

Sincerely yours,

A handwritten signature in blue ink, reading "Ronald B. Robie", is positioned below the "Sincerely yours," text.

Ronald B. Robie  
Director

Enclosure



## TABLE OF CONTENTS

	Page
SUMMARY .....	1
CONCLUSIONS .....	2
RECOMMENDATIONS .....	3
INTRODUCTION .....	5
THE NEED TO STUDY THE DELTA LEVEE PROBLEMS .....	7
Floods .....	7
Inadequate Levee Maintenance .....	7
Shortage of Public Access and Recreation Facilities .....	8
Destruction of Levee Vegetation .....	9
Earthquake Hazards .....	9
Lack of Regional Land Use Plan .....	9
Inadequate Financing .....	9
REVIEW OF ALTERNATIVES .....	11
Alternative A (No Improvement) .....	11
Alternative B (Extensive Improvement) .....	11
Alternative C (Moderate Improvement) .....	11
Alternative D (Polders) .....	11
SUMMARY OF PUBLIC MEETINGS .....	12
THE PLAN OF IMPROVEMENT .....	13
Basis for Plan Selection .....	13
Levees To Be Improved .....	13
Recreation Facilities .....	15
Levee Design .....	16
Economic Analysis .....	18
Benefits .....	18
Flood Control Benefits .....	18
Flood Damage Reduction Benefits .....	18
Land Enhancement Benefits .....	18
Erosion Reduction Benefits .....	18
Water Quality Benefits .....	18
Transportation Benefits .....	19
Recreation Benefits .....	19
Summary .....	19
Costs .....	19
Environmental Considerations .....	21
Beneficial Effects .....	21
Adverse Effects .....	21
Financing the Plan .....	22
Capital Costs for Flood Control Features .....	22
Capital Costs for Recreation Features .....	22
Possible Sources of Financing .....	24
Annual Costs .....	24
Schedule .....	24

## FIGURES

Figure Number		
1	Delta Islands Flooded Since 1930 .....	4
2	Estimated Frequency of Levee Overlapping Under Present Conditions .....	10
3	Plan of Improvement .....	14
4	Typical Sections of Vegetated Levee .....	15
5	Cross Section of Improved Levee for 100-Year Protection .....	16
6	Cross Section of Improved Levee for 50-Year Protection .....	16
7	Pie Chart Illustrating Distribution of Capital Costs .....	23

## TABLES

Table Number		
1	Preliminary Capital and Annual Costs of the Plan of Improvement .....	20
2	Distribution of Capital Costs of Plan of Improvement .....	23
3	Resources of Delta Islands .....	25

## SUMMARY

The Sacramento-San Joaquin Delta is a major resource that provides a significant contribution to the economy of California. There are many Delta problems including flood control, levee maintenance, earthquake hazards, destruction of levee vegetation, shortage of public access and recreation facilities, lack of adequate land use control and inadequate funds for levee improvement and maintenance.

Following the Sherman Island levee failure in 1969, the California Legislature under Senate Concurrent Resolution No. 151, directed the Department of Water Resources to study the problems relating to Delta levees and recommend a course of action to implement feasible solutions to the problems. Four alternative courses of action were developed and presented in an interim report in September 1973. These four courses of action were: (A) no improvement, (B) extensive levee improvement, (C) moderate levee improvement, and (D) polders (master levee systems around groups of islands).

Following the publication of the interim report, the Department of Water Resources conducted five public meetings. Hearings were held at Sacramento, Isleton, Los Angeles, Stockton and Oakland. Approximately 300 pages of testimony were recorded. The predominant comments made at the hearings and also in numerous letters were: (1) The Delta should be maintained essentially as it is today; (2) Levee improvements are needed at the earliest possible date; and (3) Federal and state funds are needed for the program.

Based on the comments on the interim report, and further studies conducted by the Department, a plan for improving the Delta levees has been developed. The recommended plan is a compromise between Alternative (B) presented in the interim report, extensive levee improvement and Alternative (C), moderate levee improvement. The plan involves improvement of 310 miles of levees that surround portions of 55 islands or tracts in the Delta. Slightly more than 45 miles of levee would be improved to 100-year protection which is considered adequate protection for some urban uses (a flood that can be expected to be equalled or exceeded on the average of once in 100 years). The remaining 265 miles of levee would be improved to provide 50-year protection which would be adequate only for agricultural land use. The plan also provides for recreation facilities, improved roads and enhancement of the environment. There would be 50 recreation access sites, of which 40 would be for fishing access. The remaining 10 would include launching ramps, parking areas, picnic facilities, fresh water supply and sanitary facilities. The preliminary estimated capital cost of the project of \$128 million is to be shared by federal, state, and local governments.

After project completion, any future levee breaks would be repaired by the owners through coverage of flood insurance or through disaster relief.

The plan of improvement has strong public support, would provide substantial socio-economic benefits, and is economically justified.

## CONCLUSIONS

- Because of unstable foundation conditions and past construction and maintenance practices, about 60 percent of the nonproject levees (those not in a federal project) in the Delta are inadequate to protect the islands from inundation and preserve the Delta channel configuration essentially as it is today. If the levees are not improved, the frequency of flooding will increase in the future.
- Because of the high cost and difficulty of repairing levee breaks, protecting the insides of the flooded islands from wavewash and pumping out the floodwater, each inundated area which is not declared a disaster area with associated federal and state financial assistance could remain permanently flooded. There will be a continuing and increasing demand for public funds for emergency repairs to levees which fail.
- If islands are permanently flooded, greater amounts of fresh water would be lost by evaporation from the flooded areas than from vegetated areas. As islands flood and levees are eroded away, the adjacent islands are in danger from increased windwave erosion. The present configuration of Delta channels and islands could become an inland sea with resultant losses in recreational use.
- There is widespread public interest in insuring that Delta islands, channels, and levees continue to be available for farming, recreation, transportation corridors, wildlife habitat, and natural gas extraction.
- To avoid undesirable urban development from occurring in areas which are not adequately protected against inundation, the counties should adopt and enforce zoning ordinances which reflect the degree of flood protection afforded to various parts of the Delta. The counties should also assure by appropriate agreement with the State, patterned after the provisions of the Cobey-Alquist Flood Plain Management Act, that they will enforce acceptable zoning ordinances following construction of improved levees as a prerequisite to receiving state financial assistance. The 1973 Flood Insurance Protection Act requires that flood insurance be purchased at the actuary rate of flooding if federally insured loans are granted for development in the flood plain.
- A reasonable degree of flood protection can be developed by rebuilding and strengthening existing levees with a staged construction period of 20 years. Significant recreation benefits can be achieved by incorporating special recreation facilities. Alternative designs, including recommendations by local districts and the counties concerning the extent of participation and recreational facilities, can be adopted to reflect local views regarding accessibility by land or water and regarding the degree of flood protection desired. Additional definite planning studies and an environmental impact report would be required prior to construction.
- It may prove as a result of future definite planning studies that continuing land subsidence will cause the rebuilding of levees on a few islands to be uneconomical. Prior to rebuilding levees on islands expected to have a limited economic life, alternatives for land use resulting in a reduction of land subsidence should be identified.
- The cost of improving the levee system can be economically justified by the flood damage reduction, land enhancement, levee erosion reduction, water quality, transportation, and recreation benefits.



- Despite the widespread public interest in the Delta, there is not a clear recognition by the general public of the need for public financial participation in insuring continued preservation of the Delta, its economy, and its resources. Consideration by the Legislature would create public awareness of responsibilities and interest in protecting the Delta.
- In view of the urgency of the Delta levee situation, the State should assume the responsibility for reconstructing the Delta levees. However, in keeping with the federal interest in flood control, there should be participation by the Federal Government through the U.S. Army Corps of Engineers in the financing of the levee improvements.
- A financing plan involving federal, state, and local funding should be developed on the basis of plans and concepts outlined in this report. Based on existing statutes and practices, the capital costs of a levee improvement program would be approximately 50 percent federal, 30 percent state, and about 20 percent local, and levee maintenance costs would be about 60 percent local and 40 percent state. Construction funds would be needed throughout a 20-year construction period.
- Inasmuch as the counties would be expected to operate the recreational facilities, it is also expected that they would provide for their necessary maintenance.
- The local levee and reclamation districts should contract with the State Reclamation Board to have their levee system included in the Delta multiple-purpose levee project; and agree to provide adequate maintenance in accordance with established standards of the improved levees.
- Existing statutes regarding formation of maintenance areas by the State in the event local districts fail to adequately maintain the levees would be applicable.

### RECOMMENDATIONS

Based on the conclusions of this report and in recognition of need to proceed with a construction program as soon as possible, it is recommended that the Legislature:

- Adopt the recommended plan of improvement of multiple-purpose Delta levees as a state plan;
- Formulate a financing program for the State's share of the capital costs; and
- Urge the U.S. Army Corps of Engineers expedite completion of its study of the federal interest in flood protection in the Delta to provide a basis for authorization of the proposed project by the Congress.

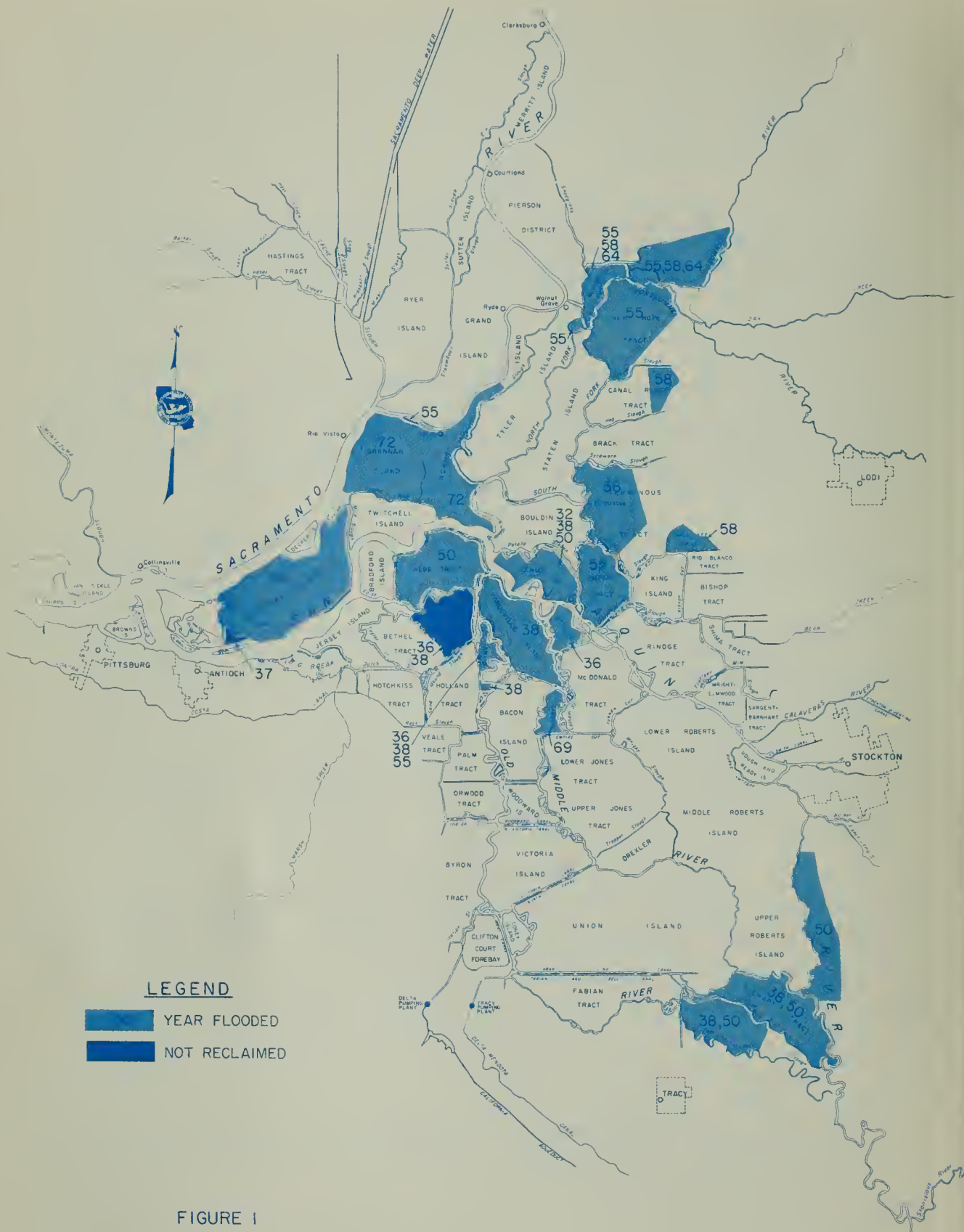


FIGURE 1  
DELTA ISLANDS FLOODED  
SINCE 1930

## INTRODUCTION

There is a long history of levee failures in the Delta which resulted in extensive economic damage. Following the levee breaks which flooded Sherman and Mildred Islands in 1969, the Legislature provided for a study to develop a plan to improve the levees in the Delta to satisfy the many needs expressed. The study was to include the feasibility of providing flood control, recreation, wildlife habitat, and environmental enhancement. An action program was requested to assure implementation of the plan of improvement.

The importance of the study and the need for improved protection of the Delta was reemphasized on June 21, 1972, when the San Joaquin River levee broke, flooding Brannon and Andrus Islands and the town of Isleton. The Delta has experienced many other similar floods. Those islands that have been flooded since 1930 are shown on the opposite page in Figure 1.

The Delta encompasses an area of over 1,100 square miles including over 700 miles of meandering, picturesque waterways. It is one of the most fertile agricultural areas in the United States, supporting a wide variety of crops which produce an annual gross income of about \$275 million. The area also contains California's most important high quality natural gas producing areas; supports one of the State's greatest fishery resources; and provides habitat for over 100 species of waterfowl and wildlife including important game and endangered species.

The Delta has become one of California's major recreation areas. It provides opportunities for fishing, boating, picnicking, camping, water sports, and sightseeing. The demand for recreational use of the Delta is steadily increasing. Additional public access and recreational facilities are needed to satisfy both present and future demands.

The Delta channels, particularly the Sacramento and San Joaquin Rivers and the two deep-water channels and ports, support important commercial shipping. Furthermore, water is transferred through these channels for use in the San Francisco Bay Area, San Joaquin Valley and Southern California. The Mokelumne Aqueduct, which conveys water from the Sierra to the Bay Area, also crosses the Delta. In brief, the Delta provides many economic and environmental benefits.

Thousands of acres of the Delta lowlands, many of which are more than 25 feet below sea level, are protected from floods and high tides by a vast network of man-made levees totaling about 1,100 miles in length. Some of these levees are over 100 years old. Many are in poor condition and need to be rebuilt.

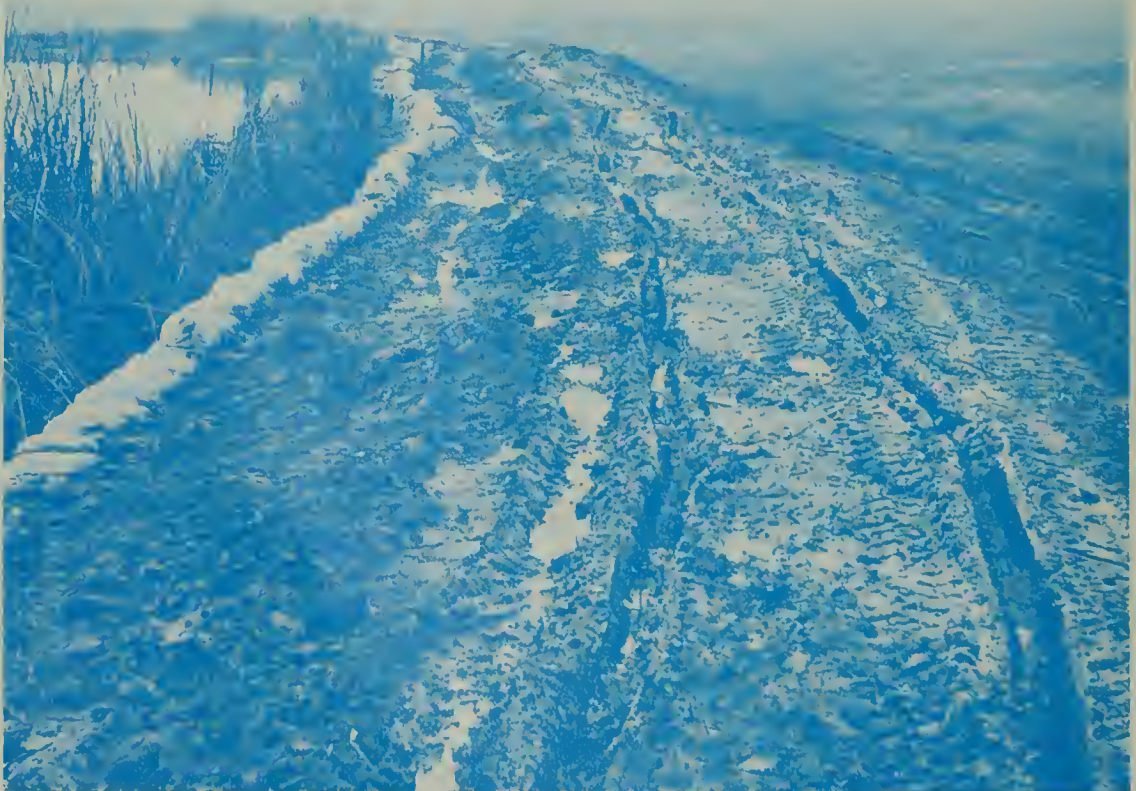
The Delta levees within the statutory Delta boundary have been classified in this study into three categories; project, nonproject, and direct agreement levees. The project levees, comprising 15 percent of the total levee system, were either built, rebuilt, or adopted as federal flood control project levees. They are maintained by local districts to federal standards.



The nonproject levees, which make up 75 percent of the levees in the Delta, were privately constructed and are maintained either by the island landowners or local agencies. The cost of maintenance is funded entirely by the landowners who many times have to minimize maintenance work, which results in the maintenance rarely being accomplished to any set of uniform standards.

Direct agreement levees, comprising the remaining 10 percent of the levees, are maintained by local districts to federal standards. They are either part of a navigation project or were rebuilt by the Federal Government after a flood disaster.

Much of the Delta is generally composed of organic peat material, which is ideal for agriculture purposes, but is poor foundation material for levees and structures. The peat has an average thickness of about 20 feet with a maximum depth of over 50 feet. The organic soil is constantly decomposing and subsiding, causing flood problems to be compounded.



*Access becomes difficult on unimproved levee roads during the winter months.*

## THE NEED TO STUDY THE DELTA LEVEE PROBLEMS

There are many problems relating to Delta levees which must be resolved if the Delta is to be preserved and protected. These problems were investigated during the course of this study and, with recommended solutions, are summarized as follows:

### Floods

Flood control provided by the Delta levee system is generally inadequate except for areas protected by federal project levees. Most of the private or nonproject levees suffer from stability problems caused by subsidence of the organic peat materials in the levee and in the foundation of the levees. As subsidence of the peat soils in the islands continues, the high water pressure in the channel becomes too great for the levees to withstand, causing a section of the levee to fail with subsequent flooding of the island. In addition, the levees are constantly being eroded by flood-flows and tidal flows and wavewash from winds, and boat wakes. Most of the levees lack sufficient freeboard during high-water periods. Many miles of levees have experienced considerable deterioration. If one island is flooded and its levees lost, the adjacent island levees are more vulnerable to wind-wave erosion. There is a potential domino effect.

The generally deteriorated conditions of the Delta levees also affect and specifically determine the socioeconomic conditions of the area. This has restricted urban development and agricultural production of high income crops. Floods have caused great financial loss to individuals and disrupted the area's economy.

To solve the inadequate flood control problem, the levee system needs to be improved. This should be accomplished by raising, widening and strengthening the embankments as needed. Where necessary, a landside berm would be constructed to serve as a counterweight for the water pressure and to serve as a base for many of the multiple-purpose features of the improved levees including roadways, parking and recreation facilities. The berms would be constructed in lifts which would be allowed to settle for approximately one year. Material would then be added to the levee crown to meet the required elevation.

### Inadequate Levee Maintenance

Levee maintenance is being performed by many agencies, districts and landowners. The quality of maintenance of nonproject levees varies according to the maintenance standards followed by the local maintaining agency. Since most maintenance organizations have to minimize costs, few of the levees are maintained to provide a high level of flood protection and to preserve vegetation, since these both increase costs.

As an interim means to assist the local agencies, Senate Bill 541, Way, was enacted as Chapter 717 of the 1973 Statutes. The bill provides for State reimbursement of a portion of the maintenance costs for nonproject levees.

Under any plan of improvement for the Delta levees, maintenance standards should be established and the improved levees should be maintained to these standards. The State Reclamation Board and the Department of Water Resources should develop proposed levee maintenance standards for multiple-purpose levees for adoption by the U. S. Corps of Engineers to supplement existing federal flood control maintenance standards. The Department of Water Resources should inspect the maintenance work performed on the improved levees to insure compliance with the required standards. This would insure that adequate levee maintenance would be performed on all improved levees.

### Shortage of Public Access and Recreation Facilities

The demand for recreational use of the Delta levees and waterways is steadily increasing. Public access to the waterways is limited and there is a shortage of levee recreational facilities and parking sites. Without sufficient public access and attractive recreational facilities, people often trespass on private levees and cause annoyance and additional expense to the landowners by littering, carelessness and acts of vandalism.

To solve these recreation related problems, public access should be provided along the improved levees, and day-use type recreation facilities constructed at approximately 50 high-use locations defined in the February 1973 Resources Agency report entitled, "Delta Master Recreation Plan". The recreation sites should be small, from 1 to 3 acres with occasional 5 to 10 acre sites. The facilities would benefit not only the recreationists, but also the Delta landowners, as they would attract the recreationists, thereby reducing trespassing on private lands and attendant trash, litter, and vandalism problems. The facilities could be developed by private interests or by state agencies, possibly with federal assistance. Public access could be provided through easements as a condition of expending public funds on the levees or by purchase, if feasible.



*Due to lack of adequate recreational facilities, people often trespass on private levees.*



### **Destruction of Levee Vegetation**

Heavily vegetated levees are difficult and costly to maintain to adequate flood control standards. Consequently, trees, shrubs and grasses have been removed from many miles of the levees. Reducing the vegetative cover has reduced the fish and wildlife habitat and food supply and decreased the natural beauty and recreational enjoyment of the Delta.

To improve this situation, a well-defined levee vegetation program would be implemented. Where feasible, trees, shrubs and grasses would be planted on the waterside slope of the levees in the area between the top of the riprap and the crown of the levees. In addition, natural vegetation which would not interfere with the flood control capability of the channels would be retained on the levees and waterside berms. Boat speed limits in some channels could reduce the need for riprapping.

### **Earthquake Hazards**

As far as is known, earthquakes have not damaged the Delta levees; however, because the levees in the lowlands of the Delta are founded on and constructed of unconsolidated peat and silt soils of low density, low shear strength, and high moisture content, there is a potential for earthquake damage. During a major earthquake, these water-saturated materials may be subjected to liquefaction, a reaction of soil and water which is similar to the movement of quicksand. Earthquake-induced seiches, or oscillations of the water surface, also could develop in the network of sloughs and river channels during a major earthquake, causing overtopping of the levees. These two types of earthquake-related phenomena should receive further evaluation to determine their significance as potential hazards in the Delta.

### **Lack of Regional Land Use Plan**

There is a need for a regional land use plan for the entire Delta area. Because of the lack of such a plan, uncontrolled encroachment of urban development is now taking place into areas which may be better suited for agriculture or open space. This in turn, causes difficulties in developing a plan for the level of flood protection to provide each area within the Delta. A long-range, coordinated plan for the orderly development of the Delta lands is essential.

The recommended solution would be for the five Delta counties to complete and enact land use plans and maintain appropriate zoning ordinances compatible with the land use plans. These ordinances should reflect the degree of flood protection afforded to the various parts of the Delta.

### **Inadequate Financing**

One of the major problems facing the Delta today is the lack of funds to develop and maintain an adequate, multiple-purpose levee system. At present, the landowners or local levee maintenance districts bear the full costs of improvement and maintenance of nonproject levees. If multiple-purpose levees are to be developed, an equitable means of obtaining adequate financing must be found.

All who would benefit from a Delta levee improvement project must share in the costs. This includes the Federal and State Governments as well as the local entities. A cost-sharing formula is discussed in this report.

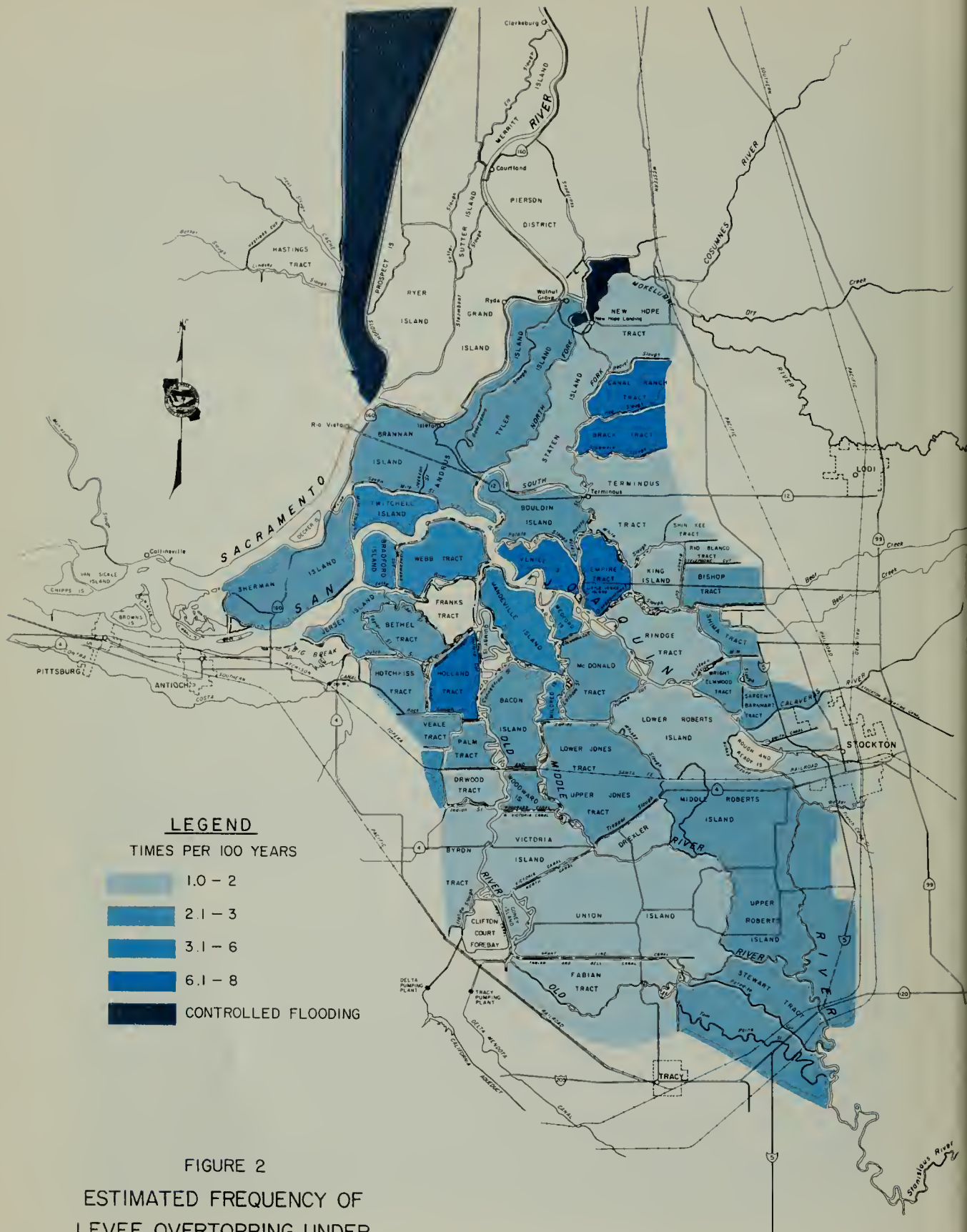


FIGURE 2  
ESTIMATED FREQUENCY OF  
LEVEE OVERTOPPING UNDER  
PRESENT CONDITIONS

## REVIEW OF ALTERNATIVES

Following the direction of the Legislature to develop a plan to protect the Delta, the Department issued an interim report entitled, "Delta Levees, What is Their Future?" in September 1973. That report presented four alternative courses of action for levee improvement ranging from no improvement to an extensive levee improvement program. The interim report was widely distributed to obtain public reaction to the concepts presented. These alternatives are briefly reviewed as follows:

*Alternative A (No Improvement).* This would not solve the levee problems which were discussed earlier. It is a course of action which would continue present levee maintenance practices and would lead to increased maintenance costs due to the continuing subsidence and erosion of the levees. At present, the average annual expenditure by the local levee and reclamation districts for levee maintenance throughout the Delta is estimated to be approximately \$250,000. This cost is expected to increase to approximately \$400,000 by the year 2020.

As subsidence and erosion increase, the frequency of levee overtopping is expected to increase from the current rate of once every 37 years to once every 29 years by 2020. This is illustrated in Figure 2, "Estimated Frequency of Levee Overtopping Under Present Conditions". Over a 50-year period, the equivalent annual cost of emergency repair and damages to public and private property from flooding is estimated to be \$4.5 million. Because of the high cost of reclaiming an island when it floods, each future flood may result in permanent inundation. The meandering Delta channels would become part of an inland sea.

*Alternative B (Extensive Improvement).* This would provide for improvement of nonproject Delta levees to protect against a once in a 100-year flood and would provide for new roads, recreation facilities, and vegetation planting to meet the maximum future needs as they arise. This would include unlimited urban development on the islands as described. The capital cost of this plan of improvement is estimated to be \$192 million.

*Alternative C (Moderate Improvement).* The lands in the Delta would be provided 50-year flood protection. This alternative would encourage the use of land for agricultural purposes. Recreation facilities and public access would be developed as an integral part of the improved levee system. The capital cost of this alternative is estimated to be \$81 million.

*Alternative D (Polders).* This embodies a concept whereby a number of islands would be linked together to form polders through the construction of embankments which close off the channels between the islands. About 250 miles of channels now exposed to the flood waters and tidal action would become interior channels. Small boat locks would be constructed where necessary. Some new roads for public access and some recreation facilities would be included where possible. There would be a loss to the anadromous fishery because of the reduced number of channels. A warm water fishery would partially compensate for this loss. This alternative would require an estimated capital cost of \$101 million.



## SUMMARY OF PUBLIC MEETINGS

The Department of Water Resources held five public meetings to receive comments on the interim report that presents four alternative courses of action. The public meetings were held in Sacramento, Isleton, Los Angeles, Stockton, and Oakland. The meetings were attended by state, federal, county and local agencies; State Water Project contractors; environmental groups such as the Sierra Club; League of Women Voters; and many interested individuals who represented a cross section of those interested in the Delta. The meetings produced constructive ideas, comments, and suggestions from a broad span of interested agencies and individuals. The information received has been carefully analyzed and considered in developing a recommended plan of improvement and an action program.

One of the principal views expressed at the five public meetings was that *something be done to improve the levees*. Other often expressed views were:

- Preserve the Delta as it is.
- No new cities – some expansion at existing urban centers.
- Need for a land use plan and zoning ordinances.
- Agriculture be provided with 50-year flood protection.
- Urban areas be provided with 100-year flood protection.
- The levees be rebuilt for multi-purpose use.
- Recreation facilities be concentrated adjacent to existing centers.
- Phase development of recreation facilities with the growing need for recreational use of the Delta.
- Provide off-levee parking to reduce safety hazard.
- The beneficiaries share in the costs.



*Public meeting packs school classroom in Isleton.*

## THE PLAN OF IMPROVEMENT

### Basis for Plan Selection

Based on the public meetings on the interim report and further studies, a general plan of improvement for the Delta levees was selected. This plan would benefit the entire Delta region by providing flood control thereby stabilizing the economy; providing open space and recreational opportunities; preserving and enhancing the wildlife habitat; and enhancing the environment. The plan of improvement would maximize long-term benefits for the area while substantially reducing the amount of public funds required for flood damage assistance. The other alternative plans considered would be less desirable for the following reasons:

1. The alternative that would provide for "No Improvement" would not solve the Delta problems and would continue great economic losses in the area.
2. Levees that would provide 100-year protection would not provide maximum net benefits, and would unduly encourage urban development thereby reducing farming use in the area.
3. Constructing a master levee system around a group of islands to form polders rather than improving levees around each individual island would cause many inconveniences. Small craft locks would be needed and there would be a loss in habitat for the anadromous fishery.

The principal element of the many plans to preserve and enhance the Delta is the provision for adequate flood control. The project proposal presented herein would provide for this need by construction of adequate levees.

### Levees to be Improved

The recommended plan of improvement would provide flood control protection to permit continuation of present land utilization. Lands presently utilized for agriculture would be protected against a 50-year flood, while the islands with urban centers, which are Brannan, Andrus, and Bethel Islands and Hotchkiss, Shima, Wright-Elmwood, Walnut Grove, and Sargent Barnhart Tracts, would be provided levees improved to withstand a 100-year flood. Furthermore, the improved levees would include desirable vegetation cover to preserve wildlife habitat and improve the esthetic appearance of the levees. Public access and recreation facilities would be included as an integral feature of the plan. The concept of this plan would be to preserve the Delta's present configuration of islands, tracts, levees and channels, farms, and open space surrounding the towns.

Where necessary, the new levees constructed principally on peat soils would have a berm similar to those shown on Figures 5 and 6. This berm would also provide a road base for new or improved roads. Approximately 150 miles of new or improved roads could be built on either the levee crown or landside berm of the improved levees.

The proposed project includes rebuilding approximately 310 miles of nonproject levees. Slightly more than 45 miles would be improved to 100-year protection standards. The remaining 265 miles would be modified to give 50-year protection. Figure 3, "Plan of Improvement", on page 14, shows the levees that would be generally improved.



FIGURE 3  
PLAN OF IMPROVEMENT



## Recreation Facilities

It is estimated that during the next 20 year period, approximately 50 recreation access sites would be established as needed. About 40 of these sites would be fishing access sites. They would be from 1 to 5 acres in size and would include parking and sanitary facilities.

The remaining 10 sites would be from 5 to 10 acres in size and would include boat launching ramps, parking areas, picnic facilities, fresh water supply, and sanitary facilities. Where feasible, the particular sites would be purchased in fee and the recreation features will become an integral part of the levee system. Access to the water areas from the public roads would be included where appropriate. Also access to some sites could be limited to boats, bicycles, and hikers.

The Delta's wildlife habitat would be restored and improved through a vegetative planting program. This vegetation would be planted on the waterside slope of the levees between the top of the riprap and the crown of the levee. On existing channel berms, vegetation would be allowed to remain where the flood carrying capacity of the channel is not threatened. The overall effects from the vegetation program would be both beneficial to wildlife and esthetically pleasing. Figure 4 illustrates typical sections of levees with vegetation planted on the waterside slope.

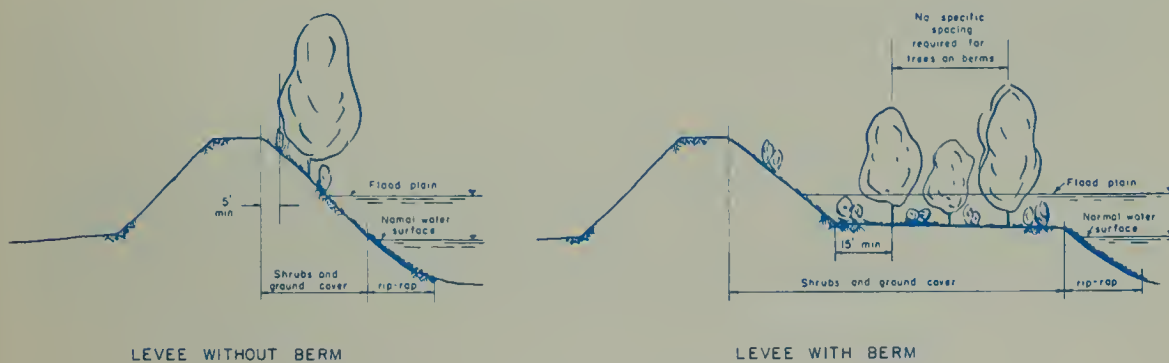


Figure 4. Typical sections of vegetated levee.

Annual levee maintenance would be performed to satisfactory flood control standards and to retain the most beneficial vegetative cover. Uniform standards for multiple-purpose levee maintenance would be developed in coordination with the U. S. Corps of Engineers to supplement the federal standards and enforced by the State Reclamation Board. The levee maintenance work would continue to be accomplished by the local levee and reclamation districts.

For those local districts which do not have the capability to provide adequate levee maintenance, the State Reclamation Board would establish a state maintenance area. Moreover, if the Reclamation Board finds that waterborne levee maintenance equipment would lower the cost of annual levee maintenance, the local maintaining agency would be encouraged to use this type of equipment.

The counties would be required to agree to establish and enforce zoning regulations commensurate with the degree of flood protection the improved levees would provide. This requirement would be consistent with the provisions of the Cobey-Alquist Flood Plain Management Act regarding locally established flood plain regulations when state funds are provided for rights-of-way for federal flood control projects.

### Levee Design

The preliminary design developed for those reaches of levee to be improved is based upon the best information currently available. Prior to final design and construction, additional foundation investigation would be necessary. This is particularly true for levees located on the deep peat soils.

Where necessary, the levees would be strengthened by placing a landside berm to act as a counterweight for high water levels in the channel. The landside berm will be required only in places where the foundation material does not have sufficient strength to support a levee of proper height and width.

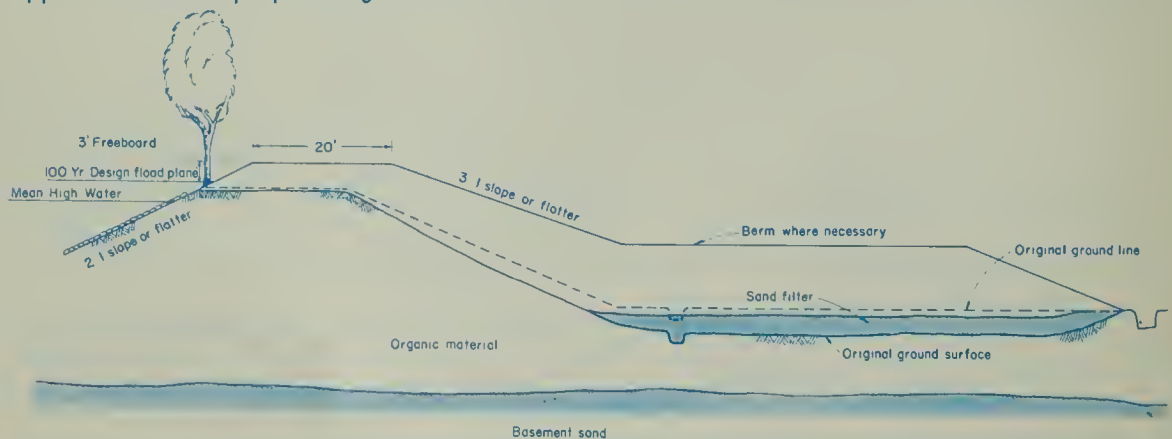


Figure 5. Cross-section of improved levee for 100-year protection.

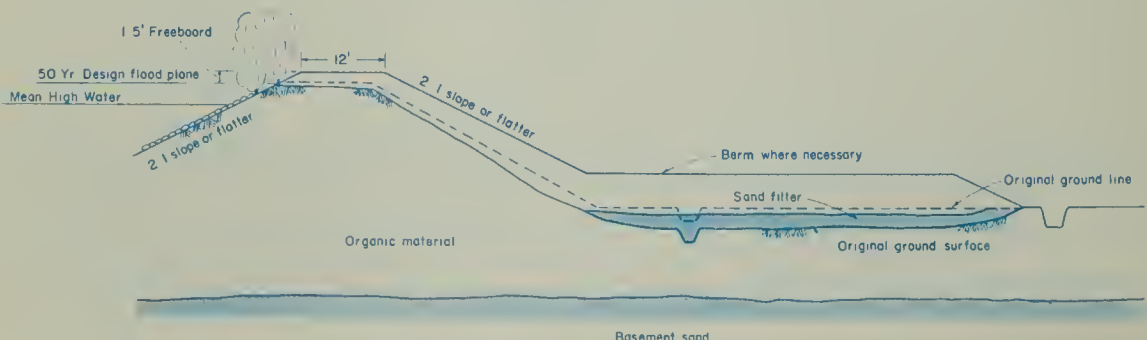


Figure 6. Cross-section of improved levee for 50-year protection.

Some of the levees to be rebuilt are located on inorganic foundation material comprised primarily of sand and some clay. Generally, this type of foundation material is much more stable under the stress of high water levels in the channel. Landside berms are seldom required to stabilize the section, but where necessary for estimating purposes, quantities of embankment were included.

The berm was designed to have about a 3 to 4 foot thick layer of permeable material such as sand to allow any water under pressure in the soil to drain out from under the added berm into an adjacent drainage ditch. Additional layers of suitable material would be placed in stages until the desired height is reached. The thickness of each layer would depend on a number of factors, such as permeability, shear strength, and the thickness of the organic material. As the berm compresses the existing peat soil, it increases in density and strength, thereby stabilizing the levee section.

Previous studies and tests of rebuilding Delta levees indicate that the berm must be raised to a height of about three times greater than the increase in height of the levee crown. After allowing the completed berm to settle for one year, the levee crown would be raised to the required height of 1.5 feet and 3.0 feet above design flood elevation for 50-year and 100-year flood protection respectively.

In rebuilding the levee section, desirable trees and shrubs such as, oaks and crepe myrtles, will be retained by selectively clearing the dead, diseased, or unwanted types of vegetation. Selective clearing is generally more expensive than total indiscriminate clearing of the levee slope, but the retention of desirable native vegetation justifies the additional expenditure.

As required, the newly constructed levees would be protected with rock riprap. Where possible, vegetation would be planted above the riprap. The criteria for rock placement on the waterside slope calls for the rock to extend from one and one-half foot above the mean high water level to two feet below mean low water level. The revetment would be 18 inches thick.

Major embankment work would be undertaken during the dry season, since the levee section and foundation are less stable when the embankment is saturated.

Approximately 14 million cubic yards of embankment would be needed to reconstruct the levees under the plan of improvement presented herein. The embankment material would be obtained by hydraulic dredging of the Delta channels and from directly offshore with a clamshell dredge, where possible. There is also considerable interest in the possibility of utilizing organic solid waste from the Bay Area as embankment material for levees, as well as for raising the island floor on a number of the Delta islands. Studies are currently underway to determine the feasibility of this proposal. This material should be adequate for building the landside berm. The environmental benefits of this program, as well as the savings resulting from reduced cost of garbage disposal may make this alternative desirable even though it may prove more costly than dredging.

In the dredging operations, every effort will be made to protect Delta water quality and fisheries. Dredging will be limited to the maximum extent possible to those times approved by state and federal fish and wildlife and water quality agencies.



## Economic Analysis

Primary direct benefits of the recommended project were evaluated in monetary terms as of 1974. Secondary benefits such as increased employment and retail sales were not considered. The reliability of the available data was comparable to that utilized for making estimates of cost and showed that the proposed project would be economically justified.

*Benefits.* The project benefits fall in two broad categories: (1) flood control and (2) recreation. Benefits stemming from flood control features are further divided into flood damage reduction, land enhancement, levee erosion reduction, water quality and transportation.

*Flood Control Benefits.* The dependence of the Delta islands and their use is uniquely tied to the levee system. Improvements to the levees would provide transportation, water quality and levee erosion reduction benefits which are considered associated with flood control along with the usual benefits from damage reduction and land enhancement.

- *Flood Damage Reduction Benefits.* The Delta was reclaimed first for agricultural purposes followed by construction of roads, utilities, and recreation and urban developments. When the levees fail and islands are inundated, crops are ruined, the transportation network is disrupted and there is great environmental and economic loss. Annual benefits are estimated to be about \$1.9 million.
- *Land Enhancement Benefits.* The unstable conditions of the levees results in adverse economic impacts in the Delta area which vary from large to minimal, depending upon the degree of protection provided by the existing levees. The risk and uncertainty of flooding under such circumstances reduces the intensity of land use for both agricultural and nonagricultural activities and reduces net returns on investments made. These risks would be reduced by improvement of the levee system and increases in land values would result. This annual land enhancement benefit is estimated to be about \$1.1 million for agriculture and \$100 thousand for urban type development for a total land enhancement benefit of \$1.2 million.
- *Erosion Reduction Benefits.* These benefits would result from prevention of damages caused by boat wakes which is a serious problem to landowners. The average annual benefit, which was computed from results described in a report by the U.S. Geological Survey, published in 1975, titled "Evaluation of the Causes of Levee Erosion in the Sacramento-San Joaquin Delta", is estimated to be about \$100 thousand.
- *Water Quality Benefits.* The Delta waterways act as major conveyance channels for fresh water for Delta needs including irrigation, fishing, and recreation. When a levee fails during times of low summertime flow, salt water from the bay and ocean is drawn through the channels into the flooded area. To repel the salt water, fresh water from upstream storage reservoirs must be released. Poor water quality brought about by more

frequent levee failures due to deteriorated levees could make irrigation more difficult for Delta farmers. This could become a substantial factor in the Delta economy in the future. The annual benefits that would result from avoiding fresh water releases for salt water repulsion are estimated to be about \$700 thousand.

- *Transportation Benefits.* Transportation benefits would accrue from an improvement of the levees and roadbeds. The resultant benefit would be a cost savings induced by the project. The average annual benefit per mile of roadbed or levee is a function of the width of the foundation and varies with each road. While private roads may not benefit as much as public roads, both would benefit from improvement of the levees. The annual benefit accruing from the reduction of cost for future construction of public roads is estimated to be about \$100 thousand.

*Recreation Benefits.* Recreation is an important economic activity in the Delta. The mobility, increased leisure time and economic affluence of the public, and the natural appeal of the Delta and its proximity to large urban areas have given rise to a flourishing recreational industry. Furthermore, since the energy crisis, the relative importance of recreation in the Delta is becoming more pronounced because recreational activities are being sought closer to home.

Under the present condition of the Delta levees, frequency of flooding would become more severe in the future and per capita recreational use would decrease. Improved levees and additional recreational facilities would greatly increase the recreational use per capita. Benefits to recreationists would also accrue from improved fish and wildlife habitat and from levee vegetative plantings.

Estimates of the increase in recreational use due to the project are about two million visitor-days per year by the 50th year of the project. The annual recreation benefits are estimated to be about \$3 million.

*Summary.* The primary direct annual benefits which would accrue from this project total about \$7 million. In addition, there are large secondary monetary benefits and widespread social and environmental benefits which would stem from implementation of a plan of improving levees and providing recreation facilities in the Delta.

*Costs.* Economic costs are the real cost of constructing and operating a project and include such things as goods, services, money, and labor, together with the tangible or intangible value of detrimental effects accruing from the undertaking. They are the actual financial costs of the proposed project, financial outlays of agencies other than the involved federal, state, and local governments, and other costs incurred by the beneficiaries in realizing these benefits regardless of the compensation to the recipient. There are two components, capital costs to construct and make necessary improvements and annual operation, maintenance and replacement costs.

The preliminary capital cost of the proposed project is \$128 million. The estimated annual operation, maintenance, and replacement cost is \$1.1 million. The estimated total equivalent annual cost of the proposed project is \$5.5 million. These costs are shown in Table 1, "Preliminary Capital and Annual Costs of the Plan of Improvement".

TABLE 1  
PRELIMINARY CAPITAL AND ANNUAL COSTS OF  
THE PLAN OF IMPROVEMENT  
(As of 1974)  
CAPITAL COST

	Total estimated capital cost including 40% engineering and contingencies
Flood Control Features	
Lands, easements, and rights-of-way	\$ 38,500,000
Selective clearing of vegetation	7,400,000
Embankment	23,500,000
Rock riprap	26,600,000
Relocation of facilities	19,400,000
Subtotal	<u>\$ 115,400,000</u>
Recreation Features	
Vegetation planting	\$ 7,200,000
Recreation lands	200,000
Recreation facilities	5,200,000
Subtotal	<u>\$ 12,600,000</u>
Total capital cost	\$ 128,000,000

#### ANNUAL COST

Equivalent annual cost of the capital cost of the project over 50 years at 5 percent interest	\$ 4,400,000
Equivalent Annual Replacement Costs	
Flood Control features	\$ 400,000
Recreation features	100,000
Subtotal	<u>\$ 500,000</u>
Average Annual Maintenance Costs	
Flood control features	\$ 400,000
Recreation features	200,000
Subtotal	<u>\$ 600,000</u>
Total Equivalent Annual Cost	\$ 5,500,000



## Environmental Considerations

When specific construction is proposed, an Environmental Impact Statement must be prepared for the project. The Department of Water Resources will work closely with the U.S. Army Corps of Engineers in the preparation of a joint federal-state EIS/EIR that will be fully processed and completed before major expenditures occur.

On the basis of the present studies, it appears that constructing the proposed project would have the following beneficial and adverse environmental effects:

### *Beneficial Effects*

- Preserve the "unique" Delta, with its islands and waterways.
- Preserve the existing native vegetation where the levee section and the vegetation is acceptable. Otherwise, the proposed development would provide for replanting acceptable vegetation on levee sections previously denuded.
- Provide public access to desirable remote recreational sites.
- Protect wildlife habitat from destruction caused by unrestricted burning or removal of vegetation.
- Reduce future vandalism and litter by concentrating public access.
- Allow unique Delta communities to retain their present identity.
- Reduce frequency of low flow summertime floods thereby improving the water quality in the Delta.
- Preserve and enhance the fishery habitat by improving vegetation on the levees and thereby increasing the fish food supply.
- Provide for enhancement of wildlife habitat areas by encouraging recreationists to use project recreational areas rather than natural wildlife habitat areas.
- Restore the natural appearance of the levees by providing desirable vegetation above the rock riprap areas.
- Provide an improved recreational resource within one hour's driving time of the major Bay Area urban areas.
- Increase in agricultural acreage in the future of from 3 to 4 acres of farmland per mile of levee by reducing seepage in the areas of deep peat soil.
- Provide a possible solid waste disposal site, if rebuilding Delta levees with solid waste compost proves feasible.

### *Adverse Effects*

- Destruction of some riparian habitat during construction of improved levees.
- Temporary loss of fish food from dredging and removal of vegetation overhanging the water ways.
- Visual appearance of rock riprap in places of high erosion.
- Loss of some farmland from production where landside berms are necessary.

## Financing the Plan

The costs should be shared by the federal, state, and county governments, and local reclamation and levee maintenance districts on the basis of apportioning such costs according to benefits. The following proposals for cost-sharing are based on established policies and practices which are in accordance with this concept. The allocated amounts are summarized in Table 2.

*Capital Costs for Flood Control Features.* The portion of the capital costs to be borne by the Federal Government was based on practice for other federal flood control projects, such as the Sacramento River Flood Control Project, as set out in the Federal Flood Control Act of 1936. The Federal Government would pay for the levee section including embankment, selective clearing, and rock riprap. In addition, when existing desirable vegetation must be removed during construction of the levee section, the cost of replacing vegetation to mitigate the loss would be a federal expense. The federal share of the costs of the levee section would approximate 50 percent of the costs of the features needed for flood control.

The nonfederal costs of rights-of-way and facility relocations required for flood control would be shared by the State and local districts. State cost-sharing policy is contained in Senate Bill 399, Lagomarsino, Chapter 893 of the 1973 Statutes. The bill provides for the State to (1) pay 75 percent of the costs of lands and rights or interest in lands whereon channel improvements are located which are apportioned to the benefits resulting from the reduction of flood damage; and (2) pay 90 percent of the costs of the relocation, reconstruction, or replacement of existing facilities rendered necessary by the project, apportioned to the benefits resulting from the reduction of flood damage. In addition to the cost-sharing policy covered in SB 399, the State would pay all of the costs of rights-of-way and facility relocations allocated to other flood control related benefits of water quality, highway transportation, and boat erosion prevention. This was based on the belief that these benefits are widespread in nature. These costs are shown in Table 2.

Local agencies are required to pay the balance of the nonfederal costs allocated to reduction of flood damage. In addition, local agencies are required to pay all of the costs apportioned to the benefits resulting from higher land use (land enhancement).

The State's share of the costs for lands and relocations would be approximately 31 percent of the costs for flood control features, and the local share would be approximately 19 percent of the costs for flood control features.

*Capital Costs for Recreation Features.* It is anticipated that the Federal Government would pay for one-half of the costs of constructing recreation facilities and planting new vegetation for enhancement of wildlife habitat as is done for other federal multiple-purpose water resources projects.

It is proposed that one-half of the nonfederal capital costs of recreation facilities and vegetation planting for enhancement of wildlife habitat would be shared by the State as prescribed by Assembly Bill No. 641, McDonald, Chapter 537 of the 1973 Statutes. The remaining one-half of the nonfederal capital costs of recreation facilities and vegetation planting would be shared by the five Delta counties. This would result in the counties paying approximately 25 percent of the costs of the recreation features of the project.

# TOTAL PROJECT COST = \$128 MILLION

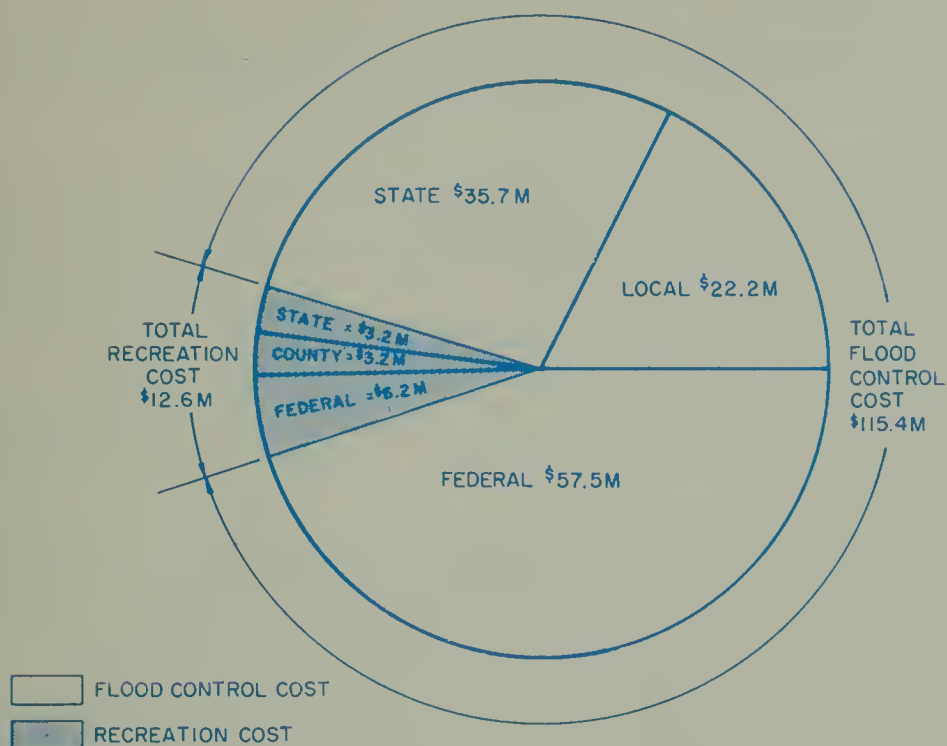


Figure 7. Pie chart illustrating distribution of capital costs.

ALLOCATION CATEGORIES	FEDERAL % \$	STATE % \$	COUNTY % \$	LOCAL % \$	TOTAL \$
Flood Control					
Flood Damage Reduction					23.5
Embankment	100				26.6
Rip rap	100				7.4
Selective Clearing	100				9.2
Relocations		90		10	18.2
Rights-of-Way		75		25	
Water Quality					
Relocations		100			3.5
Rights-of-Way		100			6.8
Highway Transportation					
Relocations		100			.6
Rights-of-Way		100			1.1
Bank Erosion Prevention					
Relocations		100			.6
Rights-of-Way		100			1.1
Land Enhancement				100	5.7
Relocations				100	11.1
Rights-of-Way					
Subtotal of Flood Control Costs	49.8	57.5	30.8	19.4	115.4
Recreation					
Vegetation Planting	50		25		7.2
Recreation Facilities	50		25		5.2
Rights-of-Way		50	50		.2
Subtotal of Recreation Costs	49.0	6.2	25.5	0	12.6
TOTAL PROJECT PER- CENTAGE & COSTS	49.7	63.7	30.3	17.5	128.0



### Possible Sources of Financing

Based on a 20-year construction schedule, 1974 construction costs, and the distribution of these costs among the entities as indicated in Table 2, annual funding requirements would be approximately as follows: the Federal Government, \$3.2 million; the State \$2 million; the five Delta counties, \$160,000; and the local Delta agencies, \$1.1 million.

Federal costs would probably be financed by annual appropriations. It is expected that funds would be available for construction rather than for reimbursement of State expenditures.

The State has some options for funding its share of the costs. Annual appropriations from the State's General Fund, or in combination with other special funds in proportion to benefits received, is one possibility. This would be the least cost alternative in the long run. A second possibility is to issue general obligation bonds, with their repayment period being twice or more that of the construction period. One advantage of this method is that all of the State's required capital funds would be available when needed.

The annual amount that each of the five counties would contribute would vary somewhat as the need for recreation facilities arises. Larger sums would be needed in some years for recreational facilities and for environmental purposes resulting from vegetation planting along the levees.

With respect to the numerous local Delta agencies, their share of the costs would be attributed to reduction in flood damage and land enhancement pursuant to Chapter 893 of the 1973 Statutes. They would not be required to share in the costs of recreation facilities, vegetation planting, or vegetation maintenance inasmuch as these costs would be borne by either the Federal, State, or County Governments.

The local Delta agencies could either assess themselves annually on a pay-as-you-go basis or issue bonds. However, it is possible that in some cases neither could be done, in which case it may be necessary for the State to establish a source of funding to provide loans to these agencies.

### Annual Costs

Annual replacement costs of the project which are required for the restoration of the flood control and recreation features would be shared in accordance with the sharing of the capital costs.

Annual costs for normal levee maintenance required for flood control would be paid for by the local districts while the added levee maintenance costs required for the preservation of vegetation would be paid by the State. An annual allocation of about \$200,000 from the General Fund would be needed to reimburse the local districts for the added costs of maintaining multiple-purpose levees. Administration of these funds would be by the Department of Water Resources as part of its levee inspection activity.

The counties would be responsible for the operation and maintenance of the recreation facilities.

### Schedule

The first work of constructing improved levees should commence as soon as federal, state, and local funding arrangements can be made. A construction period of approximately 20 years which is dictated by the time needed for adding new material as settlement of the berms and levees take place, would minimize environmental damage. By dredging only a few channels at a time, the effects on turbidity, water quality, and aesthetics can be minimized.

Criteria for allocating limited financial resources to specific islands should be developed by additional Department studies as stated above. Factors to be considered are: (1) lives to be protected, (2) willingness of local districts to participate in a cooperative federal-state-local project, (3) resources to be preserved and developed, and (4) problems encountered in rebuilding and improving Delta levees.

Table 3 shows a preliminary analysis of some of the Delta resources and the number of miles of project and nonproject levees which would be considered in developing a specific schedule with local and federal agencies.

**TABLE 3**  
**RESOURCES OF DELTA ISLANDS**

(Islands protected by non-project levees)

Tract or Island	Acres	Miles of Project Levees	Miles of Non-project Levees	Acres Per Mile of Levee	Public Roads	Gos Wells	Pipe Lines	Transmission Lines	Cities or Towns	Resorts	Railroads
Andrus	7,323	20.5	6.9	268	x	x			x	x	x
Atlas	339	0	3.1	109				x			
Bacon	5,546	0	14.0	396			x				
Bethel	3,520	0	11.5	306	x				x	x	
Bishop	2,169	0	5.8	374	x					x	
Bouldin	6,047	0	18.0	359	x					x	
Brack	4,873	0	10.8	451	x						
Bradford	2,143	0	7.4	290		x					
Brannan	7,680	10.2	3.2	572	x	x		x	x	x	
Byron	6,933	0	9.7	715	x		x	x	x	x	
Conal Ranch	2,996	0	7.5	400	x						
Coney	935	0	5.4	173							
Deadhorse	211	0	2.6	81							
Drexler	3,165	0	4.0	791	x		x	x		x	
Empire	3,725	0	10.3	362	x					x	
Fabion	6,530	0	18.7	349	x					x	
Holland	4,225	0	10.7	395	x						
Hotchkiss	3,358	0	8.4	400	x			x		x	
Jersey	3,471	0	15.6	223	x	x	x	x			
Jones, Upper	6,259	0	4.9	1,277	x		x			x	x
Jones, Lower	5,894	0	9.0	655	x					x	x
King	3,260	0	9.0	362	x	x				x	
Little Franks	333	0	3.5	95							
Mandeville	5,238	0	14.3	366							
McCormock-Williamson	1,639	0	9.1	180		x					
McDonald	6,145	0	13.5	455		x	x				
Medford	1,219	0	5.9	207							
Mildred	998	0	7.3	137			x				
New Hope	9,754	0	13.1	745	x	x		x	x	x	
Orwood	2,440	0	6.4	381	x		x			x	x
Orwood, Upper	1,698	0	4.5	317	x		x	x		x	x
Palm	2,436	0	7.5	325			x				x
Quimby	769	0	7.1	108							
Rindge	6,844	0	15.7	436	x						
Rio Blanco	667	0	3.4	196							
Roberts, Lower	10,600	0	14.6	725	x	x	x	x	x	x	x
Roberts, Middle	13,687	6.1	5.4	1,190	x	x	x	x			x
Roberts, Upper	8,260	10.6	4.4	551	x			x			
Sargent-Barnhart	1,214	1.0	2.5	290	x		x			x	
Sherman	10,420	9.7	9.8	535	x	x	x	x	x	x	
Shima	2,394	0	6.6	363				x			
Shin Kee	1,074	0	1.9	565	x						
Stark (RD 2089)	721	2.8	.7	206				x			
Staten	9,088	0	25.2	361	x	x					
Terminus	10,470	0	16.1	650	x	x			x	x	x
Twitchell	3,633	2.5	9.5	301	x	x					
Tyler	8,583	12.2	10.7	374	x	x				x	x
Union, West	15,329	0	12	929	x			x			
Union, East	9,622	1.0	13	752	x			x			
Veale	1,298	0	5.0	260	x			x			
Venice	3,220	0	12.3	262							
Victoria	7,250	0	15.1	480	x		x			x	
Walnut Grove	652	.9	2.0	225	x				x	x	x
Webb	5,490	0	12.8	428							
Woodward	1,822	0	8.9	205			x				
Wright-Elmwood	2,121	0	6.8	312	x			x		x	
TOTAL	257,730	78	503								



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